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414 Rec'd PCT/PTO 02 NOV 2000

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

REQUEST FOR FILING NATIONAL PHASE OF

PCT APPLICATION UNDER 35 U.S.C. 371 AND 37 CFR 1.494 OR 1.495

To: Hon. Commissioner of Patents (
Washington, D.C. 20231

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US)

Atty Dkt: **PM** 274429 /T298036US
M# /Client Ref.

From: Pillsbury Madison & Sutro LLP, IP Group:

Date: November 2, 2000

This is a **REQUEST** for **FILING** a PCT/USA National Phase Application based on:

1. International Application	2. International Filing Date	3. Earliest Priority Date Claimed
PCT/FI99/00366	3 May 1999	4 May 1998
⇧ country code	Day MONTH Year	Day MONTH Year (use item 2 if no earlier priority)

4. Measured from the earliest priority date in item 3, this PCT/USA National Phase Application Request is being filed within:

   (a) ☐ 20 months from above item 3 date (b) ☒ 30 months from above item 3 date,

   (c) Therefore, the due date (unextendable) is November 4, 2000

5. Title of Invention METHOD OF MEASURING SIGNAL TIMING, AND RADIO SYSTEM

6. Inventor(s) KARNA, Juha et al

Applicant herewith submits the following under 35 U.S.C. 371 to effect filing:

7. ☒ Please immediately start national examination procedures (35 U.S.C. 371 (f)).

8. ☐ **A copy of the International Application** as filed (35 U.S.C. 371(c)(2)) is transmitted herewith (file if in English but, if in foreign language, file only if not transmitted to PTO by the International Bureau) including:

   a. ☐ Request;
   b. ☐ Abstract;
   c. ______ pgs. Spec. and Claims;
   d. ______ sheet(s) Drawing which are ☐ informal ☐ formal of size ☐ A4 ☐ 11"

9. ☒ **A copy of the International Application has been transmitted by the International Bureau.**

10. **A translation of the International Application** into English (35 U.S.C. 371(c)(2))

    a. ☒ is transmitted herewith including: (1) ☒ Request; (2) ☒ Abstract;
       (3) 13 pgs. Spec. and Claims;
       (4) 2 sheet(s) Drawing which are:
       ☐ informal ☒ formal of size ☒ A4 ☐ 11"
    b. ☐ is not required, as the application was filed in English.
    c. ☐ is not herewith, but will be filed when required by the forthcoming PTO Missing Requirements Notice per Rule 494(c) if box 4(a) is X'd or Rule 495(c) if box 4(b) is X'd.
    d. ☐ Translation verification attached (not required now).

11. ☒ **PLEASE AMEND** the specification before its first line by inserting as a separate paragraph:
   a. ☒ --This application is the national phase of international application PCT/FI99/00366 filed May 3, 1999 which designated the U.S.--
   b. ☐ --This application also claims the benefit of U.S. Provisional Application No. 60/ ______, filed _____ .--

12. ☐ Amendments to the claims of the International Application **under PCT Article 19 (35 U.S.C. 371(c)(3)), i.e., before 18th month from first priority date above in item 3, are transmitted herewith (file only if in English) including:**

13. ☒ PCT Article 19 claim amendments (if any) have been transmitted by the International Bureau

14. ☐ Translation of the amendments to the claims **under PCT Article 19 (35 U.S.C. 371(c)(3)), i.e., of claim amendments** made before 18th month, **is attached (required by 20th month from the date in item 3 if box 4(a) above is X'd, or 30th month if box 4(b) is X'd, or else amendments will be considered canceled).**

15. **A declaration of the inventor** (35 U.S.C. 371(c)(4))
   a. ☐ is submitted herewith ☐ Original ☐ Facsimile/Copy
   b. ☒ is not herewith, but will be filed when required by the forthcoming PTO Missing Requirements Notice per Rule 494(c) if box 4(a) is X'd or Rule 495(c) if box 4(b) is X'd.

16. **An International Search Report (ISR):**
   a. Was prepared by ☐ European Patent Office ☐ Japanese Patent Office ☒ Other
   b. ☒ has been transmitted by the international Bureau to PTO.
   c. ☒ copy herewith (2 pg(s).) ☒ plus Annex of family members (1 pg(s).).

17. **International Preliminary Examination Report** (IPER):
   a. ☒ has been transmitted (if this letter is filed after 28 months from date in item 3) in English by the International Bureau with Annexes (if any) in original language.
   b. ☒ copy herewith in English.
   c.1 ☐ IPER Annex(es) in original language ("Annexes" are amendments made to claims/spec/drawings during Examination) including attached amended:
   c.2 ☐ Specification/claim pages #_____ claims # Dwg Sheets #
   d. ☐ Translation of Annex(es) to IPER **(required by 30th month due date, or else annexed amendments will be considered canceled).**

18. **Information Disclosure Statement** including:
   a. ☒ Attached Form PTO-1449 listing documents
   b. ☐ Attached copies of documents listed on Form PTO-1449
   c. ☒ A concise explanation of relevance of ISR references is given in the ISR.

19. ☐ **Assignment** document and Cover Sheet for recording are attached. Please mail the recorded assignment document back to the person whose signature, name and address appear at the end of this letter.

20. ☐ Copy of Power to IA agent.

21. ☐ **Drawings** (complete only if 8d or 10a(4) not completed): ___ sheet(s) per set: ☐ 1 set informal; ☐ Formal of size ☐ A4 ☐ 11"

22. Small Entity Status ∅ ☐ is **Not** claimed ☐ is claimed (pre-filing confirmation required)
22(a) ______ (No.) Small Entity Statement(s) enclosed (since 9/8/00 Small Entity Statements(s) not essential to make claim)

23. **Priority** is hereby claimed under 35 U.S.C. 119/365 based on the priority claim and the certified copy, both filed in the International Application during the international stage based on the filing in (country) FINLAND of:

	Application No.	Filing Date		Application No.	Filing Date
(1)	980982	May 4, 1998	(2)		
(3)			(4)		
(5)			(6)		

   a. ☒ See Form PCT/IB/304 sent to US/DO with copy of priority documents. If copy has not been received, please proceed promptly to obtain same from the IB.
   b. ☐ Copy of Form PCT/IB/304 attached.

RE: USA National Filing of PCT/FI99/00366

526 Rec'd PCT/PTO 02 NOV 2000

24. Attached:

25. **Preliminary Amendment:**

25.5 Per Item 17.c2, **cancel original** pages #_____, claims #_____, Drawing Sheets #

26. **Calculation of the U.S. National Fee (35 U.S.C. 371 (c)(1)) and other fees is as follows:**
Based on amended claim(s) per above item(s) ☐ 12, ☐ 14, ☐ 17, ☐ 25, ☐ 25.5 (hilite)

Total Effective Claims	minus 20 =	x $18/$9	=	$0	966/967
Independent Claims	minus 3 =	x $80/$40	=	$0	964/965
If any proper (ignore improper) Multiple Dependent claim is present,		add$270/$135		+0	968/969

BASIC NATIONAL FEE (37 CFR 1.492(a)(1)-(4)): →→ **BASIC FEE REQUIRED, NOW** →→→→

A. If country code letters in item 1 are **not** "US","BR","BB","TT","MX","IL" "NZ", "IN" or "ZA"

See item 16 re:

1. Search Report was not prepared by EPO or JPO ---------	add$1000/$500		960/961
2. Search Report was prepared by EPO or JPO ------------	add$860/$430	+1000	970/971

SKIP B, C, D AND E UNLESS country code letters in item 1 are "US","BR","BB","TT","MX","IL", "NZ", "IN" or "ZA"

(X) (only) (one) (of) (these) (4) (boxes)

→ ☐ B.	If USPTO did not issue both International Search Report (ISR) and (if box 4(b) above is X'd) the International Examination Report (IPER), --------------------	add$970/$485	+0	960/961
→ ☐ C.	If USPTO issued ISR but not IPER (or box 4(a) above is X'd), -------------------------------------	add$710/$355	+0	958/959
→ ☐ D.	If USPTO issued IPER but IPER Sec. V boxes not all 3 YES, -------------------------------------	add$690/$345	+0	956/957
→ ☐ E.	If international preliminary examination fee was paid to USPTO and Rules 492(a)(4) and 496(b) satisfied (IPER Sec. V all 3 boxes YES for all claims), -------------	add $100/$50	+0	962/963

27. **SUBTOTAL =** $1000

28. If Assignment box 19 above is X'd, add Assignment Recording fee of ----$40 +0 (581)

29. Attached is a check to cover the ----------------------- **TOTAL FEES** $1000

Our Deposit Account No. 03-3975

Our Order No.	60256	274429
	C#	M#

CHARGE STATEMENT: The Commissioner is hereby authorized to charge any fee specifically authorized hereafter, or any missing or insufficient fee(s) filed, or asserted to be filed, or which should have been filed herewith or concerning any paper filed hereafter, and which may be required under Rules 16-18 and 492 (missing or insufficient fee only) now or hereafter relative to this application and the resulting Official document under Rule 20, or credit any overpayment, to our Account/Order Nos. shown above for which purpose a duplicate copy of this sheet is attached.
This CHARGE STATEMENT does not authorize charge of the issue fee until/unless an issue fee transmittal form is filed

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NOTE: File in duplicate with 2 postcard receipts (PAT-103) & attachments.

METHOD OF MEASURING SIGNAL TIMING, AND RADIO SYSTEM

FIELD OF INVENTION

The field of the invention are radio systems and, more particularly, a CDMA radio system. The invention relates to a method of measuring signal timing to be used in the CDMA radio system comprising at least three base stations and a terminal, which multiply a signal by a spreading code, and in which method the transmission of a base station comprises various code channels transmitted by different spreading codes, on one of which code channels a predetermined symbol sequence is transmitted, and in which method the terminal is in connection with at least one base station, on whose timing the terminal stores data.

The invention also relates to a radio system, which is a CDMA radio system in particular, comprising at least three base stations and a terminal which are arranged to multiply a signal by a spreading code, in which radio system the transmission of a base station comprises various code channels transmitted by different spreading codes, at least one of which code channels comprises a predetermined symbol sequence, and the terminal is in connection with at least one serving base station, on whose timing the terminal stores data.

BACKGROUND OF THE INVENTION

It is important to determine the precise propagation time delay for a received signal in order to detect the signal and to locate a terminal, for example. In order for the terminal to synchronize itself to the transmission of a base station, each base station transmits a synchronizing signal on a sync channel. The signal on the sync channel can be demodulated and detected each time when a pilot signal is identifiable. On the sync channel, data on the base station, the power and phase of the pilot signal and the amount of uplink interference is transferred. Detecting symbols on a traffic channel is possible when the connection between a transmitter and a receiver is synchronized. The synchronized connection for its part means that the terminal is aware of the propagation time delay for the signal.

In prior art solutions, code channels whose direction of transmission is from a base station to a subscriber station, e.g. pilot channels, can be used

for synchronizing. The subscriber station can seek the code phase and then synchronize itself to the transmission of the base station and thus determine the signal timing of the base station. In the reverse direction of transmission from a subscriber station to a base station, the subscriber station begins transmitting and the base station seeks the code phase and determines the signal timing of the terminal. In the direction of transmission from a subscriber station to a base station, a problem arises which is due to the distance between a subscriber station and a base station, i.e. a near-far problem. In locating a terminal, this problem is called a coverage problem. A terminal located close to one base station is outside coverage areas of other base stations and it is not capable of hearing other base stations because of the interfering transmission of the nearby base station. As the travel time of a signal between the terminal and at least three base stations cannot be measured, the location of the terminal cannot thus be determined either.

BRIEF DESCRIPTION OF THE INVENTION

It is thus an object of the invention to provide a method and an apparatus implementing the method, in such a way that the above problems can be eliminated. This is achieved by a type of method disclosed in the introduction, which is characterized by conveying data on at least one code channel transmitted by at least one neighbour base station via a serving base station to the terminal, the terminal determining on the basis of said data the spreading code of at least one said code channel and an estimate of the symbol timing of each code channel in respect of the timing of the serving base station, and the terminal utilizing on the basis of these data on the code channels at least some of the code channels of the neighbour base station to measure the signal timing of the neighbour base station.

The system of the invention is characterized in that the serving base station is arranged to convey data on at least one code channel transmitted by at least one neighbour base station, the terminal is arranged to determine on the basis of said data at least the spreading code of at least one said code channel and an estimate of the symbol timing of each code channel in respect of the timing of the serving base station, and on the basis of data on the code channels the terminal is arranged to utilize at least some of the code channels of the neighbour base station to measure the signal timing of the neighbour base station.

The method and system of the invention provide a plurality of advantages. Coverage is improved and a terminal can also synchronize itself to the transmission of neighbour base stations, which enables the locating of the terminal.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described in greater detail in connection with the preferred embodiments, with reference to the attached drawings, in which

Figure 1 shows a radio system,
Figure 2 shows traffic channels,
Figure 3 shows a block diagram of a receiver and
Figure 4 shows a block diagram of a RAKE receiver.

DETAILED DESCRIPTION OF THE INVENTION

The solution of the invention is applicable to a WCDMA radio system (Wideband Code Division Multiple Access) in particular, yet without restricting thereto.

Figure 1 shows a radio system comprising a terminal 100, three base stations 102 to 106 and a base station controller 108. In this case, the terminal 100, which is preferably a mobile phone, can be considered primarily being in connection with the base station 102. Neighbour base stations of the base station 102 are the base stations 104 and 106. All these base stations 102 to 106 share preferably the same base station controller 108, from which there is a further connection via e.g. a mobile services switching centre (not shown in Figure 1) to the other parts of the mobile telephone network and to other telephone networks. All the other parts of the radio system except the terminals 100 are defined as the network part of the radio system.

To measure the terminal location, the travel time of a signal between the terminal and at least three base stations is needed. At first, the terminal measures the time of arrival, TOA, of a signal transmitted by each base station. Time differences between the signals of the base stations TDOA (Time Difference Of Arrival) or OTD (Observed Time Difference) can be detected by calculating the differentials of the times of arrival TOA of the base stations, when the time differences also indicate the distances between the

base stations and the terminal. When the distances between the terminal and at least three base stations is known, the terminal location can be determined unambiguously. In the CDMA system, the time of arrival can be determined by utilizing the synchronization of the spreading code. When a given chip of the spreading code (a chip is a bit of the spreading code) at the terminal appears at the instant t1 and the same chip at the base station appears at the instant t2, the travel time of the signal between the terminal and the base station is t2 - t1. The terminal measures the time t1 and the base station measures the time t2. In the solution of the invention, the terminal clock need not be synchronized with the clocks of the base stations. When the terminal transmits a so-called round-trip signal to the base station and the base station replies to this signal, the effect of the time difference between the terminal and the base station can be eliminated. If the transmission of the base stations has not been synchronized and the time differences between the base stations are not known, the round-trip must be measured from all the base stations whose signal timing the terminal measures. In a synchronized network, or if the time differences between the base stations are known, a round-trip signal is not needed for employing the TDOA method based on the time differences to determine a location. In the TOA method based on propagation time delays, a round-trip signal is only needed for the serving base station.

Even if the network was synchronized or the timing differences between the base stations were known, the round-trip signal to the serving base station can be used in determining the range for the propagation time delay to the other base stations. The terminal first measures the distance to the serving base station by using the round-trip signal. If the distance to the serving base station is d1, then the distance between the neighbour base station and the terminal is:

$$d12 - d1 - e \leq d2 \leq d12 + d1 + e$$

where d12 is the distance between the serving base station and the neighbour base station and e is the accuracy of the measurement d1. The range of the delay established this way can be utilized in estimating the propagation time delay. The range deviation of the distance between the terminal and the neighbour base station is 2(d1 + e), which corresponds to 2(d1 + e)/(c*Tc) as chips, where Tc is the duration of the chip and c is the velocity of electromagnetic radiation.

In the solution of the invention, the terminal 100 is at first in connection with at least one base station (in Figure 1, with the base station 102). At request of the terminal 100 or the network part of the radio system, the neighbour base stations 104, 106 of the base station 102 serving the terminal 100 transmit to the terminal 100 data on the transmitted code channels, an example of which is a traffic channel in particular. On the basis of the received data, the terminal 100 can also utilize some other than the sync channel in synchronizing, whereby it is possible to measure the signal timing of the neighbour base stations 104, 106 on higher interference and noise levels than in the solutions solely based on the use of the sync channel, because also the energy of a signal of other than the sync channel can be used. It is especially preferable to utilize the parts of the code channels in which a known signal is transmitted, e.g. regularly transmitted reference i.e. pilot symbols. Thus, data modulation can be eliminated from these parts without decision feedback, and a so-called coherent averaging or filtering can be used for the measured estimate of the impulse response of the channel. Let us now turn to the solution of the invention in case of using pilot symbols of the code channel.

An example of the content of the code channels transmitted by a base station is shown as a function of time in Figure 2. In this example, predetermined pilot symbols 200 are transmitted on three different traffic channels CH1, CH2 and CH3 at different instances. In order to be capable of making use of the pilot symbols 200, the terminal has to be aware of the time difference Tslot between the pilot symbols of the code channel in respect of the timing of the serving base station. On the traffic channel, besides data 204 also a transmission power symbol TPC (Transmission Power Control) is transmitted, by means of which symbol the base station can request the terminal to change its transmission power.

In order to make use of the signals of the code channel, the terminal 100 has to have data both on the time difference Tslot between the pilot symbols 200 and on the spreading code, spreading coefficient and reference symbols of the code channel. The terminal 100 needs further an estimate of the phase of the spreading code and of the location of the reference symbols in a timeslot, which data the base station 102 serving the terminal 100, the base station controller 108 or some other unit in the fixed network part requests of the neighbour base station 104, 106. The neighbour

base station 104, 106 transmits these data to the serving base station 102 preferably via the fixed network part from at least one of its code channels, which has/have the highest transmission power in the direction of the base station 102 serving the terminal. The base station 102 serving the terminal 100 transmits these data further to the terminal 100. Data on the signal timing are given to the terminal 100 preferably in respect of the timing of the serving base station 102. If the neighbour base station 104, 106 does not transmit a sufficient amount of code channels for the timing measurement to succeed, e.g. due to low congestion, the neighbour base station 104, 106 can add more channels to the transmission for the time the terminal 100 is measuring the channels. This can also happen at request of the terminal 100. It is the signal timing of these channels that is used in the inventive solution to locate the terminal 100. On these channels used particularly in locating the terminal 100, known reference symbols are preferably transmitted. When a radio system is only slightly congested, more channels can be added without substantially disturbing data transmission of other terminals. All the timings that are conveyed by the fixed network are preferably in respect of the timing of the serving base station 102.

Let us now take a closer look on a receiver of the terminal in Figure 3 applicable to the solution of the invention. The receiver comprises firstly an antenna 280, radio frequency parts 282 and an analogue-to-digital converter 284. A transmitted signal is received by the antenna 280, from which the signal travels to the radio frequency parts 282 where a quadrature demodulation is performed. In quadrature demodulation, the received signal is divided into two parts, the first of which is multiplied by a radio-frequency cosine carrier wave, which has the form $\cos(\omega_c t)$. The second part of the signal is multiplied by a phase-shifted carrier wave, which can be expressed such that the signal is multiplied by a sin carrier wave, which has the form $\sin(\omega_c t)$. Thus, the multiplication of signals employs carrier waves, between which there is a $\pi/2$ phase shift. As the different parts of the signal are orthogonal to each other due to the $\pi/2$ phase shift, data parts can be expressed in a complex manner. Thus, the received signal U can be expressed in the form $U = I + jQ$, where I is the first data part, Q is the second data part and j is an imaginary unit. The quadrature-demodulated signal parts I, Q are changed in the analogue-to-digital converter 284 to complex digital samples.

A filter 300 arranged to the code of the received signal is a FIR filter (Finite Impulse Response), whose weight coefficients are directly derived from the spreading code of the used signal. The arranged filter 300 outputs the correlation of each signal received per each signal sample by means of one delay to be measured along with the spreading code, which is loaded to the arranged filter 300 from a code generator 302. The arranged filter 300 comprises N taps, which corresponds to the delay area to be measured. As N signal samples have been driven through the arranged filter 300, the weight coefficients remaining unchanged, N correlation values have developed, preliminarily indicating an estimate of the impulse response of the channel in vector format. From the preliminary estimate of the impulse response, the effect of data modulation in a multiplier 306 is eliminated, in which multiplier the preliminary estimate of the impulse response is multiplied by a predetermined symbol sequence derived from a symbol generator 304. Thus, the estimate of the impulse response is made, and its biggest values generate delay estimations for multipath components of the signal. As the amount of noise in the signal is very high, before generating delay estimations, a series of consecutive estimates of the impulse response has to be filtered in calculating means 308 in order to establish reliable delay estimations. This is accomplished by loading the weight coefficients of the arranged filter 300 to the next N samples of the spreading code and by averaging the N-long impulse response established this way with the previous estimates of the impulse response. After the coherent averaging according to the invention is performed for the estimates of the impulse response, the delay estimations for the received signal can in principle be made. In the described receiver solution, delay estimations are, however, still specified by further processing. It is to be noticed that although the term coherent averaging is in this description connected to the estimates of the impulse response, any known filtering of the estimates of the impulse response, e.g. an IIR-based filtering (Infinite Impulse Response), can be used instead of the averaging in the receiver implementing the inventive solution. If several code channels are used for measuring timing, their known symbol sequences can be utilized by loading to the arranged filter at each instant of time the coefficients corresponding to the spreading code of the code channel by which spreading code reference symbols are received at that moment. If there is a sufficient amount of code channels in use and their time differences Tslot span the whole transmission period of the reference

symbols, the terminal can after the arranged filter constantly use a signal from which data modulation can be eliminated. The estimates of the impulse response generated in this manner can be coherently averaged, providing that the code channels to be used in measuring timing are transmitted from the same antenna of the base station, whereby they proceed along the same radio channel.

A complex IQ signal proceeds coherently from the averaging calculating means 308 to selecting means 310, at which also an output signal of the arranged filter 300 directly arrives. The selecting means 310 can thus be used for deciding, whether or not to utilize the coherent averaging. Irrespective of the fact, whether to directly select the output signal of the filter 300 or to use the coherently averaged signal components, the signal in IQ format is squared (I^2+Q^2) in means 312 before the averaging in means 314 to eliminate data modulation and phase error. As data modulation, e.g. a QPSK modulation (Quadrature Phase Shift Keying) is employed. The averaging which is performed after the selector 310 is called incoherent averaging. Employing only incoherent averaging according to the prior art has the disadvantage that besides the signal, also the noise in the output of the arranged filter 300 is squared, and thus the signal-to-noise ratio does not substantially improve after the averaging. A mere incoherent averaging helps, however, to estimate the peaks more reliably. In coherent averaging, the squaring is performed only after the coherent averaging. This requires, however, that the transmitted symbols, preferably pilot symbols, are predetermined, whereby data modulation can be eliminated from the samples.

In practice, a frequency error between the transmitter and oscillators (not shown in the figures) in the radio frequency means 282 of the receiver and the Doppler shift in the signal caused by a radio channel create phase rotating of signal samples, and so the coherent averaging time cannot be very long, e.g. about 1 ms maximum. In this case, a coherently averaged estimate of the impulse response can be squared and further averaged incoherently at a longer period of time (more than 1 ms) in the means 314. As the estimate of the impulse response proceeds to a delay estimator 316, the delay estimator 316 seeks the peaks of the estimate of the impulse response representing the most important delays of the multipath-propagated signal. The shortest delay often corresponds to the time the signal has taken to travel the direct line of sight distance. In this way, the terminal can measure the time

of arrival TOA (Time Of Arrival) of the signals of the base stations and the observed time difference OTD (Observed Time Difference) between the signals. The receiver is controlled by a control unit 318 and blocks 300 to 318 form a delay block 298, which can be a part of a RAKE receiver.

Figure 4 shows a block diagram of a RAKE receiver. The received signal travels from the antenna 280 through the radio frequency means 282 and the analogue-to-digital converter 284 as in Figure 3. Thereafter, a complex signal travels to the delay block 298, which is illustrated in more detail in Figure 3, and to RAKE branches 400 to 404 of the RAKE receiver. The blocks 400 to 404 typically comprise a code generator and an arranged filter to decode the spreading code, and each block 400 to 404 is arranged to edit the spreading-coded signal received at different delays. The delay block 298 sets the delays of the RAKE branches 400 to 404, by which the spreading coding is decoded. After the spreading codings of the signals received by the RAKE branches 400 to 404 have been decoded, different signal components of the multipath-propagated signal are combined in a diversity combiner 406, after which the baseband processing of the signal is continued, but the further processing is not substantial for the inventive solution. In the receiver, the amplification and frequency of the radio frequency means 282 is preferably adjusted by means of automatic gain control means 410 and by means of automatic frequency control means 412.

When it comes to digital signal manipulation in particular, the solutions of the invention can be implemented by e.g. ASIC or VLSI circuits (Application-Specific Integrated Circuit, Very Large Scale Integration). The procedures to be performed are preferably implemented as programs based on microprocessor technology.

Although the invention has been described above with reference to the example according to the attached drawings, it is obvious that the invention is not restricted thereto, but may be modified in a variety of ways within the scope of the inventive idea disclosed in the attached claims.

CLAIMS

1. A method of measuring signal timing to be used in the CDMA radio system comprising at least three base stations (102 to 106) and a terminal (100), which multiply a signal by a spreading code, and in which method the transmission of a base station comprises various code channels (CH1 to CH3) transmitted by different spreading codes, on one of which code channels a predetermined symbol sequence (200) is transmitted, and in which method the terminal (100) is in connection with at least one base station (102), on whose timing the terminal (100) stores data, **characterized** by

conveying data on at least one code channel (CH1, CH2, CH3) transmitted by at least one neighbour base station (104, 106) via a serving base station (102) to the terminal (100),

the terminal (100) determining on the basis of said data the spreading code of at least one code channel (CH1, CH2, CH3) and an estimate of the symbol timing of each code channel (CH1, CH2, CH3) in respect of the timing of the serving base station (102), and

the terminal (100) utilizing on the basis of these data on code channels at least some of the code channels (CH1, CH2, CH3) of the neighbour base station (104, 106) to measure the signal timing of the neighbour base station (104, 106).

2. A method as claimed in claim 1, **characterized** by the terminal (100) utilizing at least some of the predetermined symbol sequences (200) transmitted on the code channels (CH1, CH2, CH3) by the neighbour base station (104, 106) to measure the signal timing of the neighbour base station (104, 106).

3. A method as claimed in claim 1, **characterized** by the base station (102) serving the terminal (100), the base station controller (108) or some other unit in the fixed network requesting data on the code channels of at least one neighbour base station (104, 106) via the fixed network part.

4. A method as claimed in claim 1, **characterized** by the neighbour base station (104, 106) selecting for data transmission code channels (CH1 to CH3) which have the highest transmission power in the direction of the base station (102) serving the terminal (100).

5. A method as claimed in claim 1, **characterized** by the timing measurement also utilizing the sync channel.

6. A method as claimed in claim 1, **characterized** by the terminal (100) measuring the signal timing from at least three base stations (102 to 106) to locate the terminal (100).

7. A method as claimed in claim 6, **characterized** by the terminal (100) transmitting data on the signal timing of the base stations to the fixed network part of the radio system to locate the terminal (100).

8. A method as claimed in claim 6, **characterized** by the terminal (100) determining its own location by means of the signal timing.

9. A method as claimed in claim 1, **characterized** by the terminal (100) measuring the signal timing with some other neighbour base station (104, 106), if the signal timing fails with one neighbour base station (104, 106).

10. A method as claimed in claim 1, **characterized** by the neighbour base station (104, 106) adding to its transmission at least one code channel (CH1, CH2, CH3) on which a known symbol sequence is transmitted to measure the signal timing of the terminal (100), and the neighbour base station (104, 106) conveying via the serving base station (102) to the terminal (100) data, on the basis of which the terminal (100) uses said code channel (CH1, CH2, CH3) to measure the signal timing.

11. A method as claimed in claim 2, **characterized** by the terminal (100) receiving predetermined symbols (200) on several code channels (CH1 to CH3) of the same base station (102 to 106), the symbols being transmitted time-division multiplexed by the base station (102 to 106) on several channels (CH1 to CH3) in such a way that the predetermined symbols (200) of different code channels arrive at substantially different times.

12. A method as claimed in claim 2, **characterized** by the terminal (100) decoding the received spreading coding of the signal of the code channel, multiplying the signal by a predetermined symbol sequence (200) to generate an estimate of the impulse response of the channel and measuring the timing of the received signal by coherently averaging the estimates of the impulse response.

13. A radio system, which is a CDMA radio system in particular, comprising at least three base stations (102 to 104) and a terminal (100) which are arranged to multiply a signal by a spreading code, in which radio system the transmission of a base station comprises various code channels (CH1 to CH3) transmitted by different spreading codes, at least one of which code

channels comprises a predetermined symbol sequence (200), and the terminal (100) is in connection with at least one serving base station (102), on whose timing the terminal (100) stores data, **characterized** in that the serving base station (102) is arranged to convey data on at least one code channel (CH1, CH2, CH3) transmitted by at least one neighbour base station (104, 106),

the terminal (100) is arranged to determine on the basis of said data at least the spreading code of at least one said code channel (CH1, CH2, CH3) and an estimate of the symbol timing of each code channel (CH1, CH2, CH3) in respect of the timing of the serving base station (102), and

on the basis of data on code channels the terminal (100) is arranged to utilize at least some of the code channels (CH1, CH2, CH3) of the neighbour base station (104, 106) to measure the signal timing of the neighbour base station (104, 106).

14. A radio system as claimed in claim 13, **characterized** in that the terminal (100) is arranged to utilize at least some of the predetermined symbol sequences (200) transmitted on the code channels (CH1, CH2, CH3) by the neighbour base station (104, 106) to measure the signal timing of the neighbour base station (104, 106).

15. A radio system as claimed in claim 13, **characterized** in that the base station (102) serving the terminal (100), the base station controller (108) or some other unit in the fixed network part is arranged to request data on the code channels of at least one neighbour base station (104, 106) via the fixed network part.

16. A radio system as claimed in claim 13, **characterized** in that the neighbour base station (104, 106) is arranged to select for data transmission code channels (CH1 to CH3) which have the highest transmission power in the direction of the base station (102) serving the terminal (100).

17. A radio system as claimed in claim 13, **characterized** in that the terminal (100) is arranged to utilize also the sync channel in measuring the timing.

18. A radio system as claimed in claim 13, **characterized** in that the terminal (100) is arranged to measure the signal timing from at least three base stations (102 to 106) to locate the terminal (100).

19. A radio system as claimed in claim 18, **characterized** in that the terminal (100) is arranged to transmit data on the signal timing of the signals of the base stations (102 to 106) to the fixed network part of the radio system to locate the terminal (100).

20. A radio system as claimed in claim 18, **characterized** in that the terminal (100) is arranged to determine its own location by means of the signal timing.

21. A radio system as claimed in claim 13, **characterized** in that the terminal (100) is arranged to measure the signal timing with some other base station (102 to 106), if the timing measurement fails with one base station (102 to 106).

22. A radio system as claimed in claim 13, **characterized** in that the neighbour base station (104, 106) is arranged to add to its transmission at least one code channel (CH1, CH2, CH3) comprising a known symbol sequence to measure the timing of the terminal (100), and the neighbour base station (104, 106) is arranged to convey via the serving base station (102) to the terminal (100) data the terminal (100) uses in measuring the timing of the code channel (CH1, CH2, CH3).

23. A radio system as claimed in claim 14, **characterized** in that the terminal is arranged to receive the predetermined symbols (200) on various code channels (CH1, CH2, CH3) of the same base station (102 to 106), the symbols being transmitted time-division multiplexed by the base station (102 to 106) on various channels (CH1 to CH3) in such a way that the predetermined symbols (200) of different code channels arrive at substantially different times.

24. A radio system as claimed in claim 14, **characterized** in that the terminal (100) is arranged to decode the received spreading coding of the signal of the code channel, to multiply the signal by the predetermined symbol sequence (200) to generate an estimate of the impulse response of the channel and to measure the timing of the received signal by coherently averaging the estimates of the impulse response.

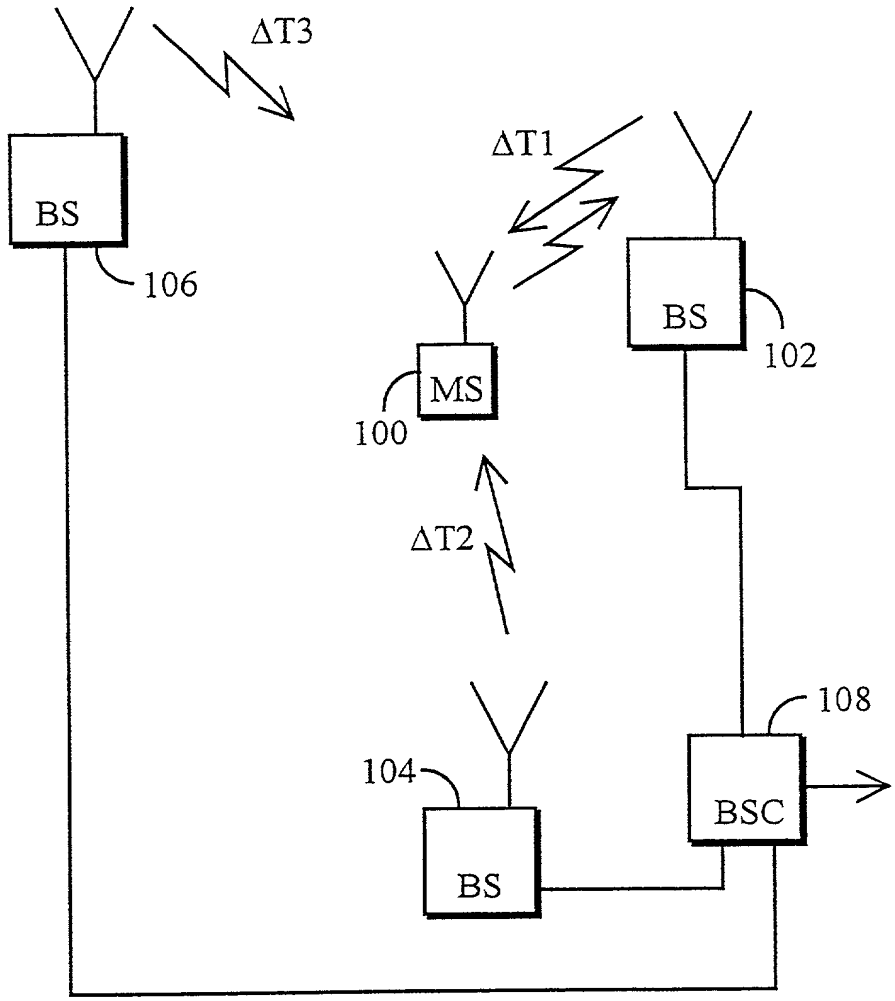

ΔT3
ΔT1
BS
106
MS
100
BS
102
ΔT2
108
104
BSC
BS

FIG. 1

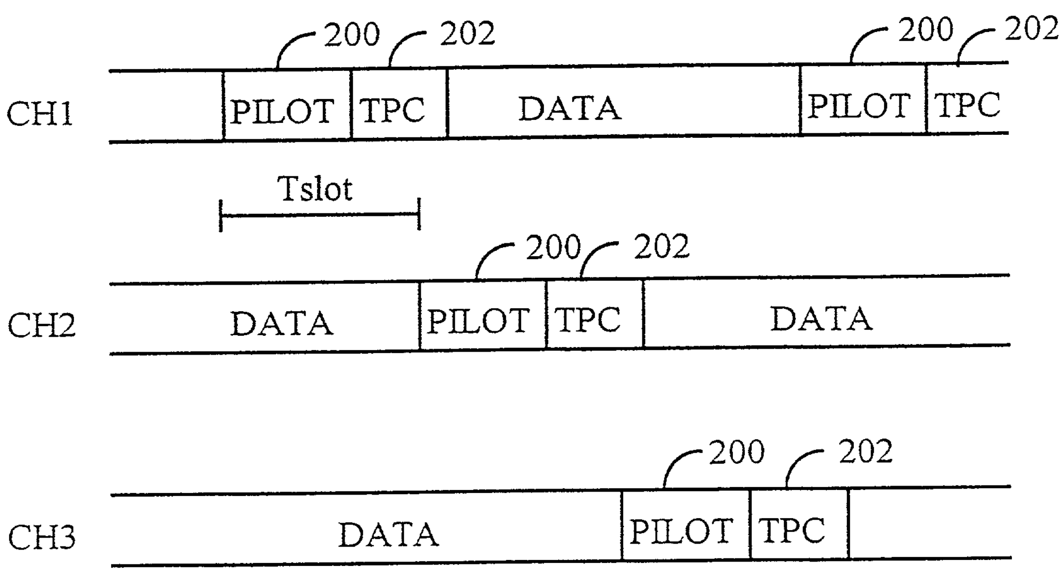
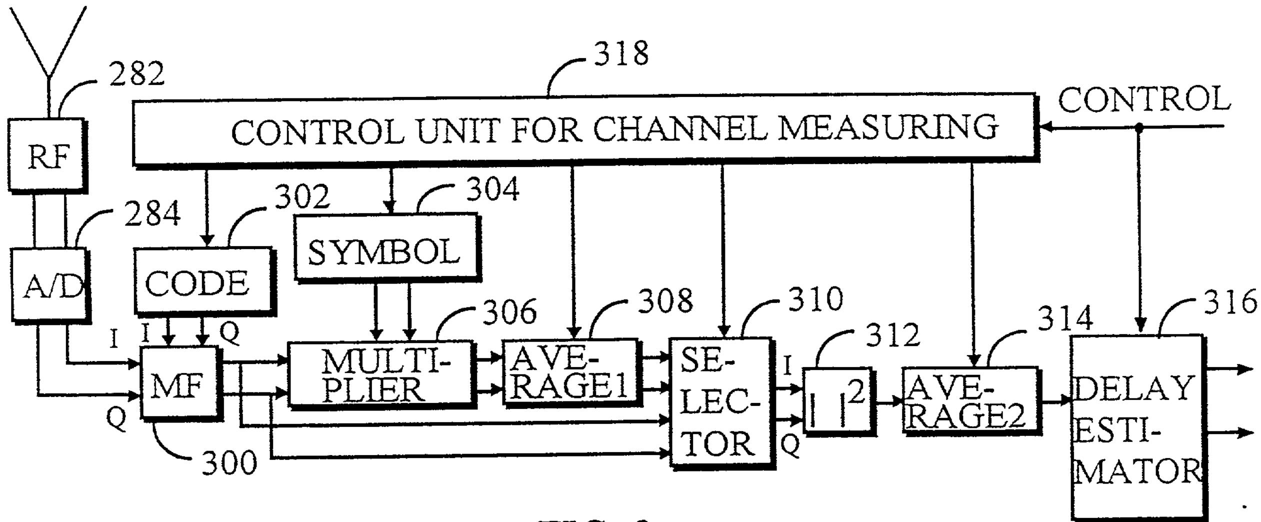
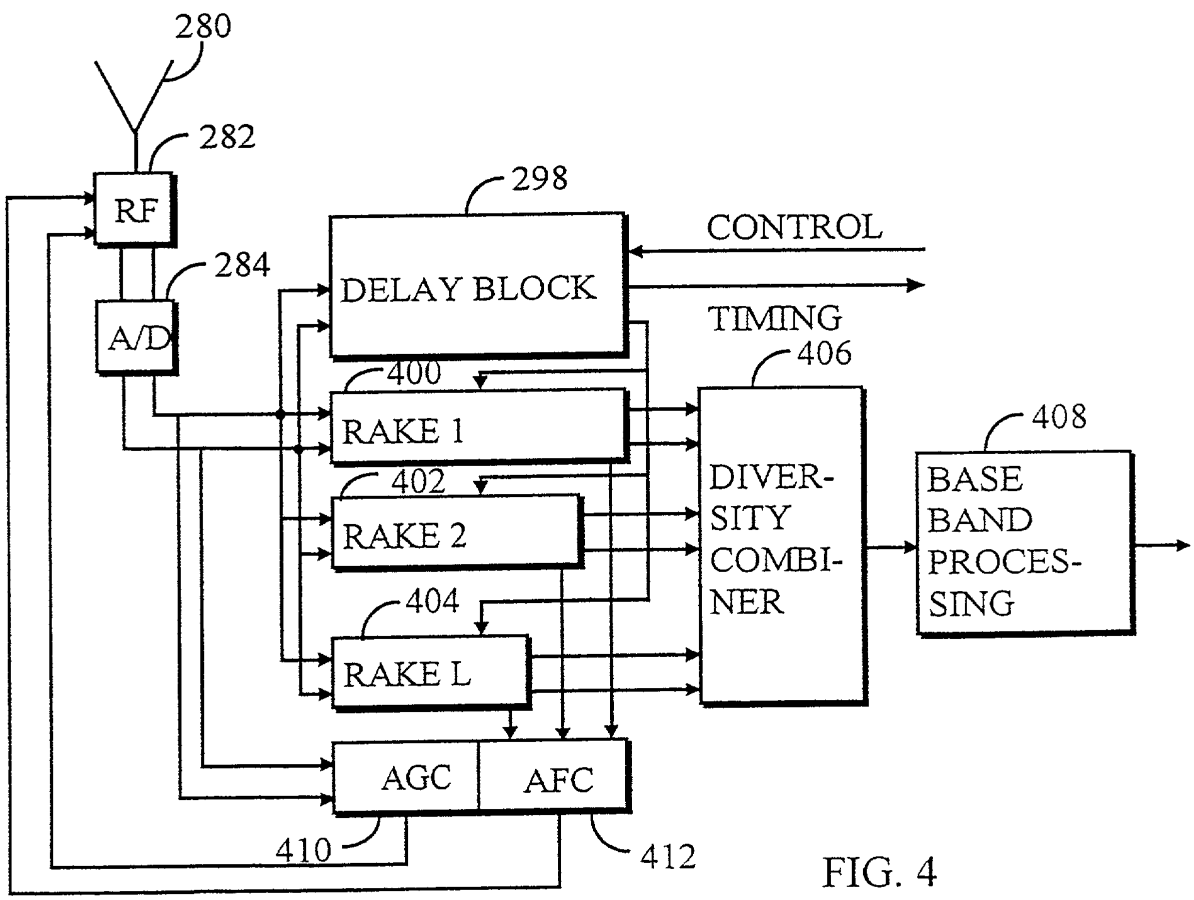

200
202
CH1
PILOT
TPC
DATA
PILOT
TPC
Tslot
CH2
DATA
PILOT
TPC
DATA
CH3
DATA
PILOT
TPC

FIG. 2



318
282
CONTROL
CONTROL UNIT FOR CHANNEL MEASURING
RF
284
302
304
SYMBOL
A/D
CODE
306
308
310
314
316
312
I
I
Q
MULTI-PLIER
AVE-RAGE1
SE-LEC-TOR
I
| |2
AVE-RAGE2
DELAY ESTI-MATOR
MF
Q
Q
300

FIG. 3



280
282
RF
298
CONTROL
284
DELAY BLOCK
A/D
TIMING
406
400
RAKE 1
402
DIVER-SITY COMBI-NER
408
BASE BAND PROCES-SING
RAKE 2
404
RAKE L
AGC
AFC
410
412

FIG. 4

1210036

FOR UTILITY/DESIGN
CIP/PCT NATIONAL/PLANT
ORIGINAL/SUBSTITUTE/SUPPLEMENTAL
DECLARATIONS

RULE 63 (37 C.F.R. 1.63)
DECLARATION AND POWER OF ATTORNEY
FOR PATENT APPLICATION
IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

PM & S
FORM

As a below named inventor, I hereby declare that my residence, post office address and citizenship are as stated below next to my name, and I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the **INVENTION ENTITLED** Method of measuring signal timing, and radio system

the specification of which (CHECK applicable BOX(ES))

X BOX(ES)
→ A. ☐ is attached hereto.
→ B. ☐ was filed on ____ as U.S. Application No. ____ / ____
→ C. ☒ was filed as PCT International Application No. PCT/ FI99 /00366 on 3 May 1999

and (if applicable to U.S. or PCT application) was amended on ____

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above. I acknowledge the duty to disclose all information known to me to be material to patentability as defined in 37 C.F.R. 1.56. I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT International Application which designated at least one other country than the United States, listed below and have also identified below any foreign application for patent or inventor's certificate, or PCT International Application, filed by me or my assignee disclosing the subject matter claimed in this application and having a filing date (1) before that of the application on which priority is claimed, or (2) if no priority claimed, before the filing date of this application:

PRIOR FOREIGN APPLICATION(S)

Number	Country	Day/MONTH/Year Filed	Date first Laid-open or Published	Date Patented or Granted	Priority Claimed Yes	No
980982	Finland	4 May 1998			x	

I hereby claim domestic priority benefit under 35 U.S.C. 119(e) or 120 and 365(c) of the indicated United States applications listed below and PCT international applications listed above or below and, if this is a continuation-in-part (CIP) application, insofar as the subject matter disclosed and claimed in this application is in addition to that disclosed in such prior applications, I acknowledge the duty to disclose all information known to me to be material to patentability as defined in 37 C.F.R. 1.56 which became available between the filing date of each such prior application and the national or PCT international filing date of this application:

PRIOR U.S. PROVISIONAL, NONPROVISIONAL AND/OR PCT APPLICATION(S)

Application No. (series code/serial no.)	Day/MONTH/Year Filed	Status pending, abandoned, patented	Priority Claimed Yes	No

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

And I hereby appoint Pillsbury Madison & Sutro LLP, Intellectual Property Group, 1100 New York Avenue, N.W., Ninth Floor, East Tower, Washington, D.C. 20005-3918, telephone number (202) 861-3000 (to whom all communications are to be directed), and the below-named persons (of the same address) individually and collectively my attorneys to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith and with the resulting patent, and I hereby authorize them to delete names/numbers below of persons no longer with their firm and to act and rely on instructions from and communicate directly with the person/assignee/attorney/firm/ organization who/which first sends/sent this case to them and by whom/which I hereby declare that I have consented after full disclosure to be represented unless/until I instruct the above Firm and/or a below attorney in writing to the contrary.

Paul N. Kokulis	16773	Dale S. Lazar	28872	Mark G. Paulson	30793	Michael R. Dzwonczyk	36787
Raymond F. Lippitt	17519	Paul E. White, Jr.	32011	Stephen C. Glazier	31361	W. Patrick Bengtsson	32456
G. Lloyd Knight	17698	Glenn J. Perry	28458	Paul F. McQuade	31542	Jack S. Barufka	37087
Carl G. Love	18781	Kendrew H. Colton	30368	Ruth N. Morduch	31044	Adam R. Hess	41835
Kevin E. Joyce	20508	G. Paul Edgell	24238	Richard H. Zaitlen	27248		
George M. Sirilla	18221	Lynn E. Eccleston	35861	Roger R. Wise	31204		
Donald J. Bird	25323	Timothy J. Klima	34852	Jay M. Finkelstein	21082		
Peter W. Gowdey	25872	David A. Jakopin	32995	Anita M. Kirkpatrick	32617		

28

(1) INVENTOR'S SIGNATURE: Juha Kärnä Date: 28.5.00

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(include Zip Code)			

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(include Zip Code)			

(FOR ADDITIONAL INVENTORS, check box ☐ to attach PAT 116-2 same information for each re signature, name, date, citizenship, residence and address.)

DECLARATION AND POWER OF ATTORNEY
(continued)
ADDITIONAL INVENTORS:

(3) INVENTOR'S SIGNATURE: A Hot   Date: 9.10.2000

3-a	Ari		Hottinen
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(4) INVENTOR'S SIGNATURE: Date:

	First	Middle Initial	Family Name
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(5) INVENTOR'S SIGNATURE: Date:

	First	Middle Initial	Family Name
Residence			
	City	State/Foreign Country	Country of Citizenship
Post Office Address (include Zip Code)			

(6) INVENTOR'S SIGNATURE: Date:

	First	Middle Initial	Family Name
Residence			
	City	State/Foreign Country	Country of Citizenship
Post Office Address (include Zip Code)			

(7) INVENTOR'S SIGNATURE: Date:

	First	Middle Initial	Family Name
Residence			
	City	State/Foreign Country	Country of Citizenship
Post Office Address (include Zip Code)			

(8) INVENTOR'S SIGNATURE: Date:

	First	Middle Initial	Family Name
Residence			
	City	State/Foreign Country	Country of Citizenship
Post Office Address (include Zip Code)			

(9) INVENTOR'S SIGNATURE: Date:

	First	Middle Initial	Family Name
Residence			
	City	State/Foreign Country	Country of Citizenship
Post Office Address (include Zip Code)			

FOR UTILITY/DESIGN CIP/PCT NATIONAL/PLANT ORIGINAL/SUBSTITUTE/SUPPLEMENTAL DECLARATIONS	RULE 63 (37 C.F.R. 1.63) DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION IN THE UNITED STATES PATENT AND TRADEMARK OFFICE	PM & S FORM

As a below named inventor, I hereby declare that my residence, post office address and citizenship are as stated below next to my name, and I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the **INVENTION ENTITLED** Method of measuring signal timing, and radio system

the specification of which (CHECK applicable BOX(ES))

X → A. ☐ is attached hereto.

BOX(ES) → B. ☐ was filed on ______ as U.S. Application No. ___/___

→ C. ☒ was filed as PCT International Application No. PCT/ FI99/00366 on 3 May 1999

and (if applicable to U.S. or PCT application) was amended on ______

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PRIOR FOREIGN APPLICATION(S) Number	Country	Day/MONTH/Year Filed	Date first Laid-open or Published	Date Patented or Granted	Priority Claimed Yes	No
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I hereby claim domestic priority benefit under 35 U.S.C. 119(e) or 120 and 365(c) of the indicated United States applications listed below and PCT international applications listed above or below and, if this is a continuation-in-part (CIP) application, insofar as the subject matter disclosed and claimed in this application is in addition to that disclosed in such prior applications, I acknowledge the duty to disclose all information known to me to be material to patentability as defined in 37 C.F.R 1.56 which became available between the filing date of each such prior application and the national or PCT international filing date of this application:

PRIOR U.S. PROVISIONAL, NONPROVISIONAL AND/OR PCT APPLICATION(S) Application No. (series code/serial no.)	Day/MONTH/Year Filed	Status pending, abandoned, patented	Priority Claimed Yes	No

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And I hereby appoint Pillsbury Madison & Sutro LLP, Intellectual Property Group, 1100 New York Avenue, N.W., Ninth Floor, East Tower, Washington, D.C. 20005-3918, telephone number (202) 861-3000 (to whom all communications are to be directed), and the below-named persons (of the same address) individually and collectively my attorneys to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith and with the resulting patent, and I hereby authorize them to delete names/numbers below of persons no longer with their firm and to act and rely on instructions from and communicate directly with the person/assignee/attorney/firm/ organization who/which first sends/sent this case to them and by whom/which I hereby declare that I have consented after full disclosure to be represented unless/until I instruct the above Firm and/or a below attorney in writing to the contrary.

Paul N. Kokulis	16773	Dale S. Lazar	28872	Mark G. Paulson	30793	Michael R. Dzwonczyk	36787
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Peter W. Gowdey	25872	David A. Jakopin	32995	Anita M. Kirkpatrick	32617		

(1) INVENTOR'S SIGNATURE: Date:

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(FOR ADDITIONAL INVENTORS, check box ☒ to attach PAT 116-2 same information for each re signature, name, date, citizenship, residence and address.)

DECLARATION AND POWER OF ATTORNEY
(continued)
ADDITIONAL INVENTORS:

(3) **INVENTOR'S SIGNATURE:** **Date:**

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	First	Middle Initial	Family Name
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	City	State/Foreign Country	Country of Citizenship
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(4) **INVENTOR'S SIGNATURE:** **Date:**

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Residence			
	City	State/Foreign Country	Country of Citizenship
Post Office Address (include Zip Code)			

(5) **INVENTOR'S SIGNATURE:** **Date:**

	First	Middle Initial	Family Name
Residence			
	City	State/Foreign Country	Country of Citizenship
Post Office Address (include Zip Code)			

(6) **INVENTOR'S SIGNATURE:** **Date:**

	First	Middle Initial	Family Name
Residence			
	City	State/Foreign Country	Country of Citizenship
Post Office Address (include Zip Code)			

(7) **INVENTOR'S SIGNATURE:** **Date:**

	First	Middle Initial	Family Name
Residence			
	City	State/Foreign Country	Country of Citizenship
Post Office Address (include Zip Code)			

(8) **INVENTOR'S SIGNATURE:** **Date:**

	First	Middle Initial	Family Name
Residence			
	City	State/Foreign Country	Country of Citizenship
Post Office Address (include Zip Code)			

(9) **INVENTOR'S SIGNATURE:** **Date:**

	First	Middle Initial	Family Name
Residence			
	City	State/Foreign Country	Country of Citizenship
Post Office Address (include Zip Code)			